

NOISE FILTER FOR AN INTEGRATED CIRCUIT

FIELD OF THE INVENTION

The present invention is relative to a noise filter, and more
5 particularly to prevent a LSI (Large-Scale integration) from the mal-
function caused by the external EMI (Electro-Magnetic Interference).

BACKGROUND OF THE INVENTION

It is known that the external Electro-Magnetic noise from a motor
10 or a breaker causes a spike noise on the power lines and signals of the
LSI will cause functional failures in the LSI.

To prevent this problem, a noise filter has been inserted between
the input pad and the input gate of the input buffer as shown in Fig 1.
This noise filter consists of a resistor and capacitor. The resistor
15 connects the input pad and the input gate of the input buffer. The
capacitor is inserted between the input gate and the ground of the LSI.

If the noise pulse is applied between the input pad and the ground
line, the noise pulse is absorbed by the noise filter and the noise is not
detected by the input buffer.

20 As far as the voltage between VDD and VSS is kept the same (This
condition is called the Common Mode) and the time constant of the RC
network is big enough, the noise filter of the prior art can prevent the
LSI from the mal-function.

However if the following conditions happen, the noise filter of the
25 prior art is not good enough anymore.

(1)The noise filter of Fig. 1 cannot prevent the noise, in case the noise is applied between VDD and VSS (This condition is called the Normal Mode).

(2)High resistance poly-silicon is not available in the deep sub-
5 micron LSI.

(3)The time constant cannot be made big enough when the cycle time is small, in other words the clock frequency is high.

SUMMARY OF THE INVENTION

10 The object of the present invention is to provide a noise filter to prevent an LSI from the mal-function caused by the external EMI.

Another object of the present invention is to provide a noise filter having a long time constant.

Another object of the present invention is to provide a noise filter
15 that can operate in high frequency.

According to the present invention, a noise filter for an integrated circuit comprises:

a CMOS inverter having an input and an output, the input of the CMOS inverter being coupled with an input pad of the integrated circuit,
20 the output of the CMOS inverter being coupled with an input buffer;

a first capacitor being inserted between the output of the CMOS inverter and a first voltage source; and

a second capacitor being inserted between the output of the CMOS inverter and a second voltage source.

25 In accordance with one aspect of the present invention, the integrated circuit is a LSI.

In accordance with one aspect of the present invention, the integrated circuit is a VLSI.

In accordance with one aspect of the present invention, the input buffer is a schmitt trigger.

5 In accordance with one aspect of the present invention, the CMOS inverter includes a NMOS transistor and a PMOS transistor.

In accordance with one aspect of the present invention, the first voltage source is VDD and the second voltage source is VSS.

10 According to the present invention, a noise filter for an integrated circuit comprises:

a transition circuit having an input and an output, the input of the transition circuit being coupled with an input pad of the integrated circuit, the output of the transition circuit being coupled with an input buffer;

15 a first capacitor being inserted between the output of the transition circuit and a first voltage source; and

a second capacitor being inserted between the output of the transition circuit and a second voltage source.

20 In accordance with one aspect of the present invention, the integrated circuit is a LSI.

In accordance with one aspect of the present invention, the integrated circuit is a VLSI.

25 In accordance with one aspect of the present invention, the transition circuit includes two transfer gates, the two transfer gates are a NMOS transistor and a PMOS transistor.

In accordance with one aspect of the present invention, the input buffer is a schmitt trigger.

In accordance with one aspect of the present invention, the first voltage source is VDD.

In accordance with one aspect of the present invention, a reference voltage of the transition circuit is $VDD/2$.

5 In accordance with one aspect of the present invention, the second voltage source is VSS.

The present invention may best be understood through the following description with reference to the accompanying drawings, in
10 which:

BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1 shows the new noise filter of the prior art;

Fig.2 shows the noise filter of the present invention;

Fig.3 shows another embodiment of the new noise filter.

15

DETAIL DESCRIPTION OF THE PREFERRED EMBODIMENT

The new noise filter 21 shown in Fig. 2 consists with one CMOS inverter 211 and two capacitors 212,213. The input gate of the inverter 211 is coupled with the input pad 13, and the output of the inverter 211
20 is coupled with the input gate of the input buffer 14. The first capacitors 212 is inserted between the output N1 of the inverter 211 and the VDD of the LSI and the 2nd capacitor 213 is inserted between the output N1 of the inverter 211 and the VSS of the LSI.

By using the present invention, we can overcome the problems of
25 the prior arts listed in the previous page as explained below.

(1) In case a noise is applied between VDD and VSS, the input voltage of the input buffer which is stored in the two capacitors, changes

according to the voltage between VDD and VSS because the voltage between VDD and VSS is divided by the two capacitors 212,213. The threshold voltage of the input buffer 14 also changes according to the voltage between VDD and VSS. Assuming the threshold voltage of the input buffer is $(VDD+VSS)/2$, then the threshold voltage is kept $(VDD+VSS)/2$ even when the voltage between VDD and VSS is changed. Assuming the input voltage of the input gate is higher than the threshold voltage in the beginning, then the input voltage is kept higher than the threshold voltage even when the noise is applied between VDD and VSS and the voltage between VDD and VSS is changed. Then the noise is not detected by the input buffer.

(2) As the new noise filter of this invention does not use resistors but uses normal CMOS inverter, it does not need any high resistance materials such as high resistivity poly-silicon. Because it uses CMOS transistors instead of resistor, we can easily get high resistance and modify resistance without consuming big silicon area.

(3) In case the clock frequency is high, we could not make the time constant big enough in case of the prior art. However in the new noise filter, the current flowing through N-ch transistor of the CMOS inverter and the current flowing through P-ch transistor of the CMOS inverter compensates each other, it makes the time constant of the noise filter big enough when the input voltage is around the threshold voltage of the input buffer. That is, the time constant of the new noise filter 21 is not the constant, but it changes according to the input voltage. The time constant is small when the voltage is close to VDD or VSS. But the time constant becomes big when the input voltage reaches around the threshold voltage of the input buffer.

Another embodiment of the present invention is shown in Fig.3. Instead of CMOS inverter, transfer gates 311, 312 with applying the reference voltage ($V_{DD}/2$) is utilized. The transfer gates 311, 312 compose a transition circuit and they are a PMOS transistor 311 and a
5 NMOS transistor 312. When the input voltage is close to the VDD or VSS, one of the transfer gate is turned on and the resistance of the transfer gate becomes small, but when the input voltage is around the threshold voltage of the input buffer, both transfer gates 311, 312 turned off and the resistance of the transfer gate becomes infinite. The
10 reference voltage ($V_{DD}/2$) can be changed such as, VDD-1.5V to the gate of the P-ch transistor and 1.5V to the gate of the N-ch transistor.

By using this new noise filter, we can prevent the noise to affect the input buffer without sacrificing the silicon area nor the clock frequency.

15 By using MOS transistors as the resistors instead of passive resistors, we can save the additional process for high resistivity polysilicon and we can easily control resistance of the noise filter without using large silicon area.

As the time constant of the new noise filter is small when the input
20 voltage is close to VDD or VSS but it is big when the input voltage is around the threshold voltage of the input buffer, the new noise filter can protect the noise efficiently without sacrificing the signal frequency.

While the invention has been described in terms of what are presently considered to be the most practical and preferred embodiments,
25 it is to be understood that the invention need not be limited to the disclosed embodiment. On the contrary, it is intended to cover various modifications and similar arrangements included within the spirit and

scope of the appended claims which are to be accorded with the broadest interpretation so as to encompass all such modifications and similar structures.